



Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

CAUSES OF FAILURE IN CAST IRON PIPE¹

By F. A. McINNES²

In Boston, during the past twelve years, nineteen failures of cast iron water pipe, 16 to 48 inches in diameter, have occurred; nine of them due to settlement upon an unyielding support, three to accident (in two cases blasting, and in the third case the operations of a public service corporation), two to freezing, one to imperfect casting, two to demoralization of metal in "bad ground;" in two cases no reason for failure was apparent. As usual the fatal rigid bearing was the greatest offender. Eternal vigilance, expressed in unremitting inspection on the part of the Water Department, will alone minimize the danger from this cause in city streets. The pipe may be originally laid in a safe location, yet disaster may easily follow from the subsequent construction of sewers, conduits, subways, etc., under or adjoining it. All the failures of this kind mentioned above were due to settlement upon structures built after the pipe was laid, and all might have been avoided had reasonable care been taken to provide the necessary clearance around the pipe.

It is not my intention to discuss the damage resulting from electrolysis, bad ground, improper filling, undue external loading, settlement, etc., nor to go at length into the imperative necessity that cast iron pipe be well made, properly laid and carefully protected from adverse conditions after being put in service. Much might be written on these points, but I will leave that task to others. I propose to call attention briefly to a probable cause of failure neither so much discussed nor appreciated. I refer to the quality of the pipe iron. This vital feature has not been sufficiently safeguarded in our specifications, which require the test bars to support a centre load of 1900 pounds (N.E.W.W.) or 2000 pounds (Am.W.W.) and to show a deflection of 0.3 inch before breaking. The weak spot in these requirements lies in the fact that no direct connection is made between the loading and deflection with the result that in many

¹ Presented before the Philadelphia Convention, May 18, 1922.

² Division Engineer, Public Works Department, Water Division, Boston, Massachusetts.

cases the test bars do not show 0.30 inch deflection until the load is in excess of 1900 or 2000 pounds, often times largely in excess. 2183 test bars broken by the Metropolitan Water Board of Massachusetts during the past nine years give the following results:

- 3 bars showed 0.18 inch deflection at 1900 pounds.
- 5 bars showed 0.19 inch deflection at 1900 pounds.
- 33 bars or 15 per cent of total number showed 0.20 to 0.21 inch deflection at 1900.
- 389 bars or 18.0 per cent of total number showed 0.22 to 0.24 inch deflection at 1900.
- 229 bars or 10.5 per cent of total number showed 0.25 to 0.28 inch deflection at 1900.
- 437 bars or 20.0 per cent of total number showed 0.28 to 0.30 inch deflection at 1900.
- 905 bars or 41.5 per cent of total showed less than 0.30 inch deflection at 1900.
- 456 bars or 21.0 per cent of total number showed 0.31 to 0.34 inch deflection at 1900.
- 490 bars or 22.5 per cent of total number showed 0.35 to 0.37 inch deflection at 1900.
- 136 bars or 6.0 per cent of total number showed 0.38 to 0.40 inch deflection at 1900.
- 3 bars showed 0.42 inch deflection at 1900.
- 2 bars showed 0.43 inch deflection at 1900.

These results indicate metal of widely different quality. With a test bar deflection at 1900 pounds ranging from 0.18 to 0.43 inch, we may safely conclude that the iron varied from "very hard" to "very soft." Omitting the extreme cases, the deflection at 1900 pounds ranged from 0.22 to 0.37 inch, a condition far from satisfactory.

Water pipe iron, to insure the required resiliency and the necessary strength, should show a test bar deflection of approximately 0.3 inch at 2000 pounds with an increased deflection of approximately 0.03 inch for each increase in load of 200 pounds above 2000 pounds.

The question naturally arises, "Why not specify the composition of the iron, stating just what percentage of the different elements will be allowed, as is done in the manufacture of steel?" There are practical objections to this course based on the differences in ores and coke throughout the country, on the necessarily different composition of thick and thin pipe, on the practical difficulty of making such a provision effective, on the possible undesirability of specifying both physical characteristics and composition of metal.

The writer, however, believes that the permissible sulphur content at least should be specified. With this provision, together with a logical relation between flexure and breaking load fixed in the test bar requirement, a long step forward towards uniform and satisfactory iron will have been taken.

It has been the practice of the Boston Water Department to analyze the metal in a broken or cracked pipe, and the following determinations represent some of the results obtained over a period of approximately twenty years. Many other analyses, entirely above suspicion, have been made in the same period.

YEAR	SIZE	SIL.	SUL.	MAN.	PHOS.	C.C.	G.C.	REMARKS
	<i>inches</i>							
1920	8	1.32	0.177	0.85	0.64	0.82	2.70	Pipe broken in middle of length when unloading from truck
1919	12	1.66	0.205	0.28	0.75	1.38	1.71	Sleeve broken when water was turned on
1918	8	1.74	0.233	0.45	0.83	1.30	2.20	Pipe broken when water was turned on
1915	10	1.37	0.171	0.57	0.75	0.72	2.68	Pipe broken in transit from foundry
1915	12	1.65	0.185	0.48	0.75	0.69	2.70	Pipe broken in transit from foundry
1915	10	1.35	0.133	0.43	0.79	0.64	2.74	Pipe broken in transit from foundry
1915	10	1.33	1.21	0.40	0.80	0.64	2.70	Pipe broken in transit from foundry
1915	12	1.47	1.21	0.34	0.80	0.93	2.40	Pipe broken in transit from foundry

Six breaks occurred between October 19 and December 5, 1900, in a 48-inch supply main of the Boston System, laid in 1869, following an increase in working pressure of 15 pounds. The analyses of the iron in these cases were as follows:

	SIL.	SUL.	MAN.	PHOS.	C.C.	G.C.
1	4.05	0.07	0.90	1.00	0.04	2.38
2	4.25	0.017	0.90	0.79	0.08	3.56
3	4.10	0.037	0.83	0.86	0.08	2.85
4	4.18	0.027	0.93	0.90	0.08	3.06
5	4.27	0.051	0.86	0.928	0.06	2.62

When the writer was employed in St. John, N. B., 1916-1917, one of the two 24-inch mains supplying the city failed several times, as it had been in the habit of doing at intervals in the past. The pipe was cast in England many years ago. The following are analyses of the metal in the broken pipe in three cases:

	SIL.	SUL.	MAN.	PHOS.	C.C.	G.C.
1	2.94	0.035	1.08	0.99	0.56	2.59
2	2.36	0.068	1.22	1.00	0.51	2.79
3	2.80	0.03	1.05	0.90	0.58	2.80

The following analyses of a 24-inch main broken in the Hartford, Conn., system in 1921, have come to my attention:

	SIL.	SUL.	MAN.	PHOS.	C.C.	G.C.
1	2.22	0.094	0.36	1.39	0.07	2.92
2	2.61	0.10	0.23	1.86	0.03	2.77

Some of these determinations may safely be termed "horrible examples;" witness the Boston 48 inch with C.C. 0.04, Sil. 4.05 and the Hartford 24 inch with C.C. 0.03, Phos. 1.86. One of them, the St. John 24 inch, is in the freak class. The remainder, particularly those in which the sulphur content is abnormally high, warrant the conclusion that the quality of the iron was a contributing, if not the direct, factor in the failure of the pipe. The broken pipes were cast in main pipe foundries throughout the United States, with two exceptions, namely, the St. John 24 inch which was made in England and the sleeve broken in 1915, which was cast in a small jobbing foundry in Boston. As a rule, two specimen pieces, taken from different parts of the broken pipe, were submitted for analysis and in no case was a substantially different result obtained from the bell and spigot end of the same pipe.

Cast iron pipe is not a homogeneous material. When pig iron and scrap iron are melted and made into water pipe, the resulting cast iron must vary to some extent in its physical characteristics, owing to differences in the material used in the cupola and to the methods employed in moulding, cooling, etc. The process of manufacture demands a high degree of skill and oversight of the product to maintain the uniform quality desired. That this condition does

not always exist is apparent to those familiar with the output of cast iron water pipe. There are notable exceptions where this criticism does not apply, but on the whole it would appear that the general standard of manufacture might be raised to the advantage alike of maker and consumer, to the end that a well coated pipe of uniform and sufficient strength, equal at least to the best of the present product, may be absolutely depended upon.

The writer is one of those who believe in cast iron pipe for water works distribution and supply systems, recognizing it to be best suited to meet the conditions usually found, and as its friend, advocates the application of more scientific methods in its manufacture than now obtains in many cases.